1,053,337

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to Electrical Transformers

We, INTERNATIONAL BUSINESS MACHINES CORPORATION, a Corporation organized and existing under the laws of the State of New York in the United States of America, of 590 Madison Avenue, New York 22, State of New York, United States of America (assignees of COMPAGNIE IBM FRANCE) do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electrical transformers and to methods of producing such transformers.

Transformers according to the present invention are simple in construction and may be employed in any application in which they are subjected only to relatively low-strength electric current. Apart from the simplicity of their manufacture, transformers according to the present invention possess several advantages over transformers of the prior art; in accordance with this invention it is possible, for example, to produce a core-less transformer having a transformer ratio substantially equal to 1, and to incorporate in the transformer an electrostatic screen which is practically perfect.

According to a first aspect of the present invention, an electrical transformer comprises a conductor wire constituting a primary circuit of the transformer and covered by a plurality of alternately insulating and conducting layers, one of the conducting layers constituting a secondary circuit of the transformer and the length of the layers being such that the ends of the conductor wire and the ends of each conducting layer are exposed to facilitate the fixing of electrical connections thereto.

Preferably a conducting layer between the conductor wire and said one conducting layer constitutes an electrostatic screen.

According to a second aspect of the present invention, a method of producing a transformer according to said first aspect comprises suspending the conductor wire in a first bath with the ends of the wire exposed above the level of the liquid in the bath so that a layer of insulating material deposited on the wire from said liquid terminates short of the ends of the wire, suspending the wire in a second bath or baths with a greater part of the length of the wire adjacent each end being exposed above the level of the second liquid or liquids so that a layer of conducting material deposited on the insulating layer terminates short of the insulating layer at each end, and then suspending the wire again in the first bath and second bath or baths successively, with still greater lengths of the wire adjacent each end thereof being exposed above the liquid level during each successive deposition step so that each layer deposited on the preceding layer terminates short of that preceding layer.

An alternative method of producing a transformer according to said first aspect of the present invention comprises covering the whole length of the conductor wire with a plurality of alternately insulating and conducting layers, and subsequently removing selected end parts of each layer so that at each of its ends each layer terminates short of the immediately underlying layer and the insulating layer in contact with the conductor wire terminates short of that wire at each end. An advantage of this alternative method is that it facilitates the additional removal of selected intermediate parts of some of said layers, when such removal is desired.

Some embodiments of the present invention will now be described by way of example, with reference to the accompanying drawings, in which:

Fig. 1 shows an axial section through part of a layer-covered conductor wire,

Figs. 2 and 3 show transformers comprising the layer-covered wire of Fig. 1,

Fig. 4 is a schematic representation of a method of producing a transformer,

Fig. 5 shows an axial section through part of a second layer-covered conductor wire, and

Figs. *6a* and *6b* together schematically

represent an alternative method of producing a transformer.

Referring first to Fig. 1, a central conductor wire 1 is provided with an insulating layer 2, a conducting layer 3, another insulating layer 4, and another conducting layer 5. The wire 1 and the layers 3 and 5 are preferably of copper, and the layers 2 and 4 are preferably of a cellulose lacquer. In practice the thickness of the layers 2 to 5 is very much smaller than the diameter of the conductor wire 1, and in the drawings the thickness of these layers has been exaggerated for the sake of clarity.

It will be seen from Fig. 1 that the lengths of the respective layers 2 to 5 are such that the layer 2 terminates short of the ends of the wire 1 and each succeeding layer terminates short of the ends of the layer which precedes it. The result of this stepped formation is that the ends of the wire 1 and of each of the conducting layers 3 and 5 are exposed to facilitate the fixing (preferably by soldering) of electrical connections thereto.

Such connections are shown in Fig. 2, where the conductor wire 1 is to be used as the primary circuit of the transformer, the outer conducting layer 5 is to be used as the secondary circuit, and the intermediate conducting layer 3 is to constitute an electrostatic screen. Wires 1*a* and 1*b* are soldered to the ends of the wire 1 to feed the primary current thereto. Wires 5*a* and 5*b* are soldered to the ends of the layer 5, and a centre tapping is effected by soldering a wire 5*c* to the layer 5 substantially midway of its length. The layer 3 is earthed by a single wire 3*a* since it is to function as an electrostatic screen. With this arrangement the transformer ratio is equal to 1 if the output tappings 5*a* and 5*b* are used, and is less than 1 if the tappings 5*a* and 5*c* or 5*b* and 5*c* are used. The roles of the conductor wire 1 and the layer 5 can naturally be reversed, in which case a transformer ratio greater than 1 is obtained.

It will be seen that in Fig. 2 the layer-covered wire 1 is disposed in coiled formation and constitutes a core-less transformer. Fig. 2 is intended principally to show the disposition of the layer covered conductor wire and it is to be understood that the Figure does not accurately illustrate the relationship in practice between the diameter of the layer-covered wire and the diameter of the various loops in the coil. Moreover in practice the coils would probably comprise more than five loops.

Fig. 3 shows a cored transformer obtained by passing the layer-covered wire of Fig. 1 through a ferrite cylinder 10. It will be observed that in this embodiment the transformer has two secondary circuits, since both the conducting layers 3 and 5 are provided with terminal output wires 3*a*, 3*b* and 5*a*, 5*b* respectively.

Fig. 4 is a schematic representation of a method of producing the layer-covered wire of Fig. 1. In this method the copper conductor wire 1 is first coiled over part of its length in order to avoid variations in shape which can result from the manipulation of a wire already covered with layers. The wire 1 is then suspended by its ends 11 and 12 from a platform 13 and is subsequently plunged successively into an etching bath 14, a bath 15 of cellulose lacquer for deposition of the insulating layer 2, and a series of chemical or electrolytic baths such as 16 and 17 for the formation of the copper layer 3. It is then plunged once more into the bath 15 and the baths 16, 17 for the formation of the layers 4 and 5. Each time that a new layer is deposited, a greater length of the wire adjacent each end thereof is exposed above the surface of the liquid in the bath in question, so that the first deposited layer (2) terminates short of the wire 1 at each end and each succeeding layer 3, 4 and 5 terminates short of the one before it. When all the layers have been deposited the required electrical connections are soldered to the conducting layers, as shown by way of example in Figs. 2 and 3.

With the layer-covered wire of Fig. 1 it is possible to solder an electrical connection to the outermost layer 5 at any point along the length of the latter (as in the case of the centre tapping 5*c* in Fig. 2) but such connections can be soldered only to the end portions of the layer 3 and conductor wire 1 since they are the only portions of that layer and wire which are exposed. Sometimes, however, (for example in the case of a transformer having several centre-tapped secondary circuits) it is necessary to have access to intermediate points on the wire 1 or to such points on a layer which is not the outermost layer.

An example of this is shown in Fig. 5 where the copper conductor wire 1 is covered with layers 2 to 9, the even-numbered layers being of insulating material such as cellulose lacquer and the odd-numbered layers being conducting layers of copper. The conducting layers 5 and 9 constitute secondary circuits, having centre-tapping connections represented by wires 5*c* and 9*c* respectively, and the conducting layers 3 and 7 constitute electrostatic screens. Since intermediate parts of the layers 9 and 7 have been removed to allow the the centre-tapping to be effected, wires 9*d* and 7*d* are provided in order to ensure the electrical continuity of those layers.

Figs. 6*a* and 6*b* schematically illustrate a method by means of which selected parts of various layers can be removed from an initially totally covered wire 1 in order to allow both end- and centre-tappings to be effected, as in the construction shown in Fig. 5. The part of the process represented by Fig. 6*b* is an immediate continuation of the part illustrated in Fig. 6*a*.

The method comprises passing the layer-covered wire through a series of tanks containing appropriate liquid baths and through a

number of sleeves the function of which will be described later herein. The wire passes through apertures provided in the walls of the tanks, and liquid which escapes through those apertures is collected and pumped back to the appropriate tank.

The element (indicated at F in Figs. 6*a* and 6*b*) which is subjected to this process comprises a central conductor wire initially covered troughout its length with alternately insulating and conducting layers as already described. The element F is successively passed through:

—a bath 20 comprising a solution of a photosensitive product capable of being rendered insoluble in water by exposure to intense light or to ultravoilet rays. Such a product can be constituted, for example, by a mixture of polyvinyl alcohol solution and an ammonium bichromate solution.

—an opaque sleeve 21 having a translucent part 21*a* of small length; an arc lamp 22 projects on to the part 21*a* a luminous beam rich in ultraviolet rays to render insoluble the photosensitive layer deposited by the liquid of the bath 20; the lamp 22 is switched off during the intervals of time corresponding to the passage of those parts of the element F from which the external layer 9 must subsequently be removed; the operation of the lamp 22 is synchronized with the drive mechanism for the element F; this synchronization being obtainable by means well known in the art, the synchronization devices will not be described.

—a tepid water bath 23 to dissolve the layer of photosensitive product coming from the bath 20 at those parts where it has not be subjected to the action of the arc lamp 22.

—an acid bath 24 to dissolve the copper layer 9 at the places where the layer of photosensitive product has been removed by the bath 23.

—a bath 25 resembling the bath 20.

—a sleeve 26 resembling the sleeve 21 and lit by an arc lamp 27 which is switched off during intervals of time corresponding to the passage through the translucent part 26*a* of those parts of the element F from which the insulating layer 8 must subsequently be removed.

—a tepid water bath 28 to dissolve the layer of photosensitive product which has not been exposed to the arc lamp 27.

—a methyl acetate bath 29 to dissolve the cellulose varnish layer 8 at the places where the photosensitive product has been removed by the bath 28.

—a bath or photosensitive product 30 resembling the baths 20 and 25.

—a sleeve 31, lit by an arc lamp 32 whose periods of extinction correspond to the length of the parts to be removed from the conducting layer 7.

—a series of baths and sleeves not shown in the Figures and successively comprising baths resembling 23, 24, 25, a sleeve resembling sleeve 21, baths resembling baths 28, 29, 30, a new sleeve resembling sleeve 21, and so on, the duration of extinction of the arcs associated with the sleeves growing smaller in a manner corresponding to the lengths of the parts which it is desired to remove from the layers 6, 5, 4, 3 and 2.

WHAT WE CLAIM IS:—

1. An electrical transformer comprising a conductor wire constituting a primary circuit of the transformer and covered by a plurality of alternately insulating and conducting layers, one of the conducting layers constituting a secondary circuit of the transformer and the length of the layers being such that the ends of the conductor wire and the ends of each conducting layer are exposed to facilitate the fixing of electrical connections thereto.

2. A transformer according to claim 1, wherein a conducting layer between the conductor wire and said one conducting layer constitutes an electrostatic screen.

3. A transformer according to claim 1 or claim 2, wherein said one conducting layer is additionally exposed at a point intermediate its ends to facilitate the fixing of an electrical connection to that exposed point.

4. A transformer according to any one of claims 1 to 3, additionally comprising a magnetic core.

5. A transformer according to any one of claims 1 to 4, wherein the layer-covered conductor wire is disposed in a coil formation.

6. A transformer according to any one of the preceding claims, wherein the conductor wire is a copper wire, each conducting layer is a layer of copper, and each insulating layer is a layer of cellulose lacquer.

7. An electrical transformer substantially as herein described.

8. An electrical transformer substantially as herein described with reference to Fig. 1, Fig. 2, Fig. 3 or Fig. 5 of the accompanying drawings.

9. A method of producing a transformer according to claim 1, comprising suspending the conductor wire in a first bath with the ends of the wire exposed above the level of the liquid in the bath so that a layer of insulating material deposited on the wire from said liquid terminates short of the ends of the wire, suspending the wire in a second bath or baths with a greater part of the length of the wire adjacent each end being exposed above the level of the second liquid or liquids so that a layer of conducting material deposited on the insulating layer terminates short of the insulating layer at each end, and then suspending the wire again in the first bath and second bath or baths successively, with still greater lengths of the wire adjacent each end thereof being exposed above the liquid level during each successive deposition step so that each layer deposited on the preceding layer termi-

nates short of that preceding layer.

10. A method according to claim 9 wherein the conductor wire is subjected to an etching step before it is suspended in said first bath for the first time.

11. A method according to claim 9 or claim 10, wherein the conductor wire is coiled over part of its length before it is suspended in said first bath for the first time.

12. A method according to claim 9, substantially as herein described.

13. A method according to claim 9, substantially as herein described with reference to Fig. 4 of the accompanying drawings.

14. A method of producing a transformer according to claim 1, comprising covering the whole length of the conductor wire with a plurality of alternately insulating and conducting layers, and subsequently removed selected end parts of each layer so that at each of its ends each layer terminates short of the immediately underlying layer and the insulating layer in contact with the conductor wire terminates short of that wire at each end.

15. A method according to claim 14, wherein selected intermediate parts of some of said layers are also removed.

16. A method according to claim 14 or claim 15, wherein said selected parts removed by being dissolved in baths of appropriate liquids, the remaining parts of the layers being provided with a coating which is resistant to the action of those liquids.

17. A method according to claim 14, substantially as herein described.

18. A method according to claim 14, substantially as herein described with reference to Figs. 6*a* and 6*b* of the accompanying drawings.

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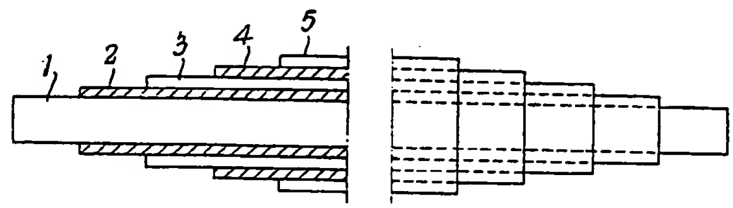

FIG.1

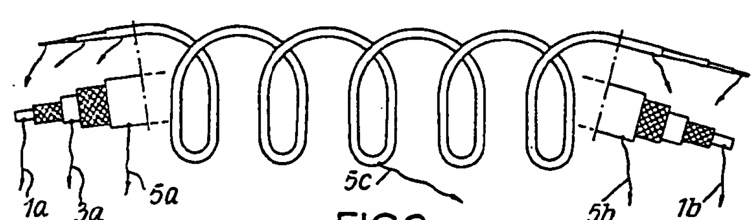

FIG.2

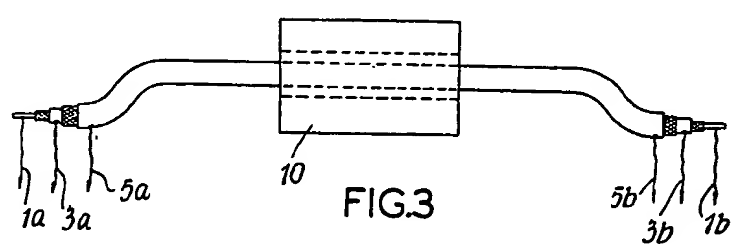

FIG.3

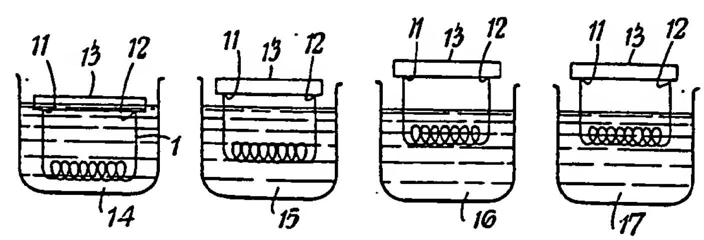

FIG.4

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2 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheets 1 & 2

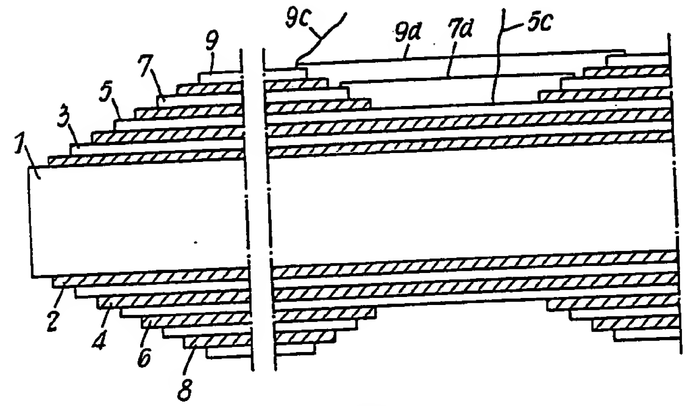

FIG5

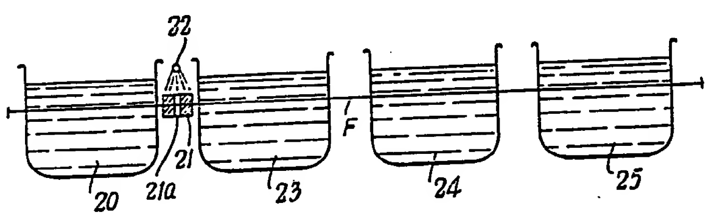

FIG.6a

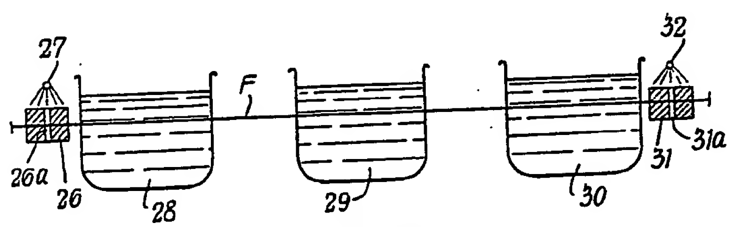

FIG.6b

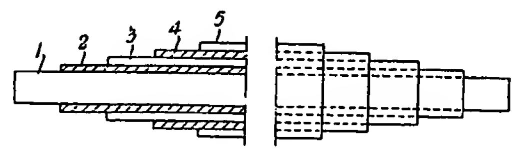

FIG.1

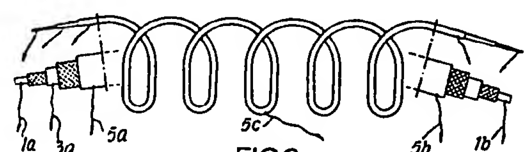

FIG.2

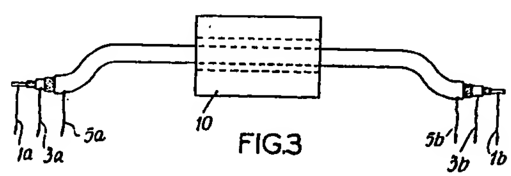

FIG.3

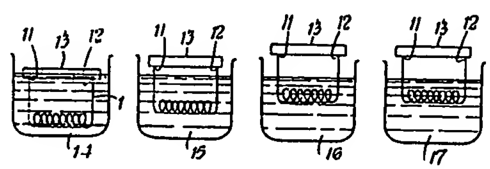

FIG.4

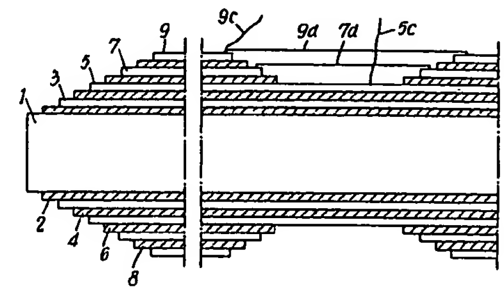

FIG5

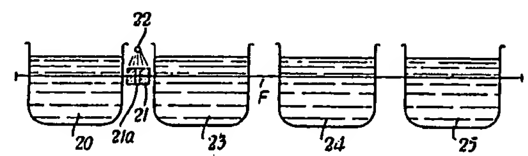

FIG.6a

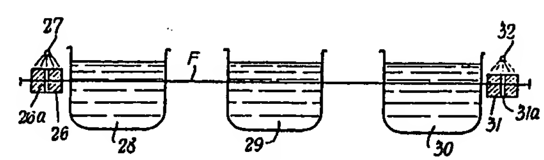

FIG.6b